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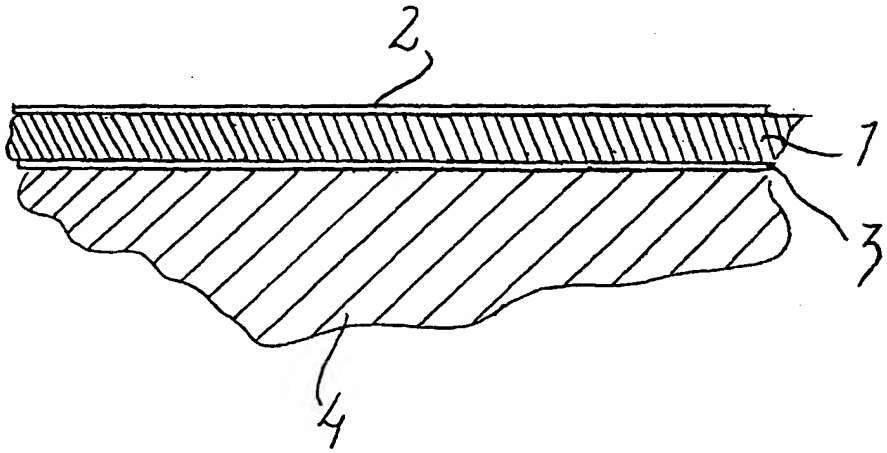
(54) Title: WEAR RESISTANT SURFACE AND A METHOD FOR ITS MANUFACTURING



(57) Abstract: A method for the manufacturing of a hard wear resistant surface of PVD-material on a soft foundation or on large objects, wherein a piece of metal sheet of hard material is coated by means of a PVD-method with a layer of PVD, which is harder than the metal sheet, and wherein the metal sheet or parts thereof is then glued, with the side that is facing away from the PVD-coating, at the position on the softer foundation or larger object, in which the wear resistant surface is desired. Since the meal sheet, that preferably may have the shape of a tape, is hard the layer of PVD is supported, so that the deformations at the expected point loads become so small that the layer of PVD does not fracture.

WO 01/00402 A1

WEAR RESISTANT SURFACE AND A METHOD FOR ITS MANUFACTURING

Surface coatings produced with the PVD-method are increasingly used for protecting different kinds of surfaces against abrasion and friction. Carbides, nitrides, borides, oxides and so forth are used, which have a hardness far exceeding those of normal materials used for construction. This can multiply the lifespan of components exposed to wear.

New methods of manufacturing PVD-layers and new coating materials increases the possibilities to achieve layers, which are very hard as well as elastic at the same time. Carbon based layers, such as carbon nitride, is an example of such of layer, where a very exact control of the process leads to graphite planes being bent and tangled in each other, to a very hard and, at the same time, elastic structure.

Another means of increasing the elasticity of the layer is to build it up using many thin layers, so that the generation of defects and fractures is stopped in the interfaces of the layers. Nanocrystallic layers with a particle size in the range of nanometres also have similar characteristics. Also the manufacture of such multi-layers or nanocrystallic coatings require very well controlled process conditions.

The use of layers of PVD is however limited by a number of factors, of which the primary ones are the following:

Limited space for coating: The method is carried out in vacuum. This means that the entire object to be coated must be placed in a vacuum chamber, together with one or several coating sources, even if it is only a few limited areas, which need coating. This result in practical and economic hindrances to the coating of larger objects.

Complicated process: A number of factors influence the quality of the layer, such as temperature, gas pressure, as well as the angle and distance of the coating sources supplying the material, of which the layer is built. This leads to the process parameters having to be adjusted to the object in every individual charge, to the coating of larger objects becoming increasingly difficult, as well as to the possibility of coating of holes and indentations being limited. The limitations are even more pronounced for the more advanced layers of PVD, such as carbon

nitride, nanocrystalline and multi-layers.

Hard supporting substrate material: The characteristics of the layers of PVD are requested in situations with high surface loads, whilst the layer in itself is so thin that it does not possess any supporting capacity of its own. Usually objects to be coated by PVD must therefore be made of hard construction material, preferably hardened steel. The basic material then has such a hardness that remaining deformation is prevented and the layer is therefore not peeled off due to the material below it being scratched.

Enduring the coating temperature: The substrate material must be resistant to the temperature, to which it is exposed during coating, being a minimum of 200 °C for optimal quality of the layer. This excludes a range of materials, such as plastic, zinc and case-hardened structural steel used for construction, as well as many cold formed objects, which would be deformed by the temperature of the coating.

Correct state of surface: The heavily loaded thin layer of PVD also poses high demands on the state of the surface to be coated, especially regarding the surface fineness. A well ground or polished surface, which is left untouched by the treatment is usually required, which may be difficult to accomplish in complicated geometries. At the same time it is required that the entire object is free of contaminations, which may evaporate during the process of coating.

The object of the present invention is to provide a method with which to protect even large objects, internal and hidden surfaces, objects made of softer material of construction or of material not resistant to 200 °C, as well as surfaces lacking the right coating conditions, from wear and tear and friction, using layers of PVD (such as carbides, nitrides, borides, oxides, etc).

This object is attained by applying the layer on a thin strip or sheet of metal, which is hard enough to provide the layer with sufficient supporting capacity, and which is then applied on the surfaces exposed to wear and friction, instead of applying it directly onto the objects.

By applying the layer of PVD on a tape or strip, which is wound between two spools in front of the source of the coating, large areas can be coated in a very cost efficient manner. In the continuous process, full control over the factors influencing the quality, such as temperature, as

well as angle and distance of the source of coating, is possible. In this way the constant conditions necessary for the most advanced layers of PVD are achieved.

The thin tape or sheet of metal is advantageously of hardened steel, such as martensite stainless steel, which is available in thin strips or tapes. The expensive alloy materials, which are needed to support the layer are then concentrated to the tape, whilst the rest of object can be manufactured in a simpler material. The surface of the tape is machined and heat-treated in an efficient manner to the required surface condition and hardness. During the coating, the tape is oriented so that the edges or burrs from the slitting of the tape are oriented backwards, alternatively the tape is at the slitting impressed so that the edge or burr is made more even.

The thickness of the tape should be sufficient to support the layer, but yet sufficiently thin so that the tape can be formed to fit the surfaces, onto which it is to be attached.

At mounting on the wear surfaces the tape is cut into pieces of suitable lengths and applied preferably with some form of adhesive. The adhesive can be applied at mounting or during the manufacturing of the tape. In the latter case, the tape is delivered as a self-adhesive tape. By choosing a layer of PVD with a surface energy lower than that of the lower side of the tape, the adhesive will stay on the bottom side when the belt is rolled off.

Cutting preferably takes place in an I-shaped punching tool, so that the edge or burr of the cut pieces are turned downwards, preventing wear to be initiated on the edge.

By winding the tape in a spiral and cutting it off diagonally, it can also be used for protecting radial surfaces both externally and internally.

Since the PVD-layer supporting tape (or its surface layer) is hard, it will not at point loads (within reasonable limits) be deformed more than the elasticity or plasticity of the PVD-layer allow and thereby avoiding that the layer of PVD, especially if it has a crystalline structure, is broken and destroyed. Also at point loads a very good resistance to wear, low friction and a high strength is obtained and no scratches appear, resulting in a long lifespan. The invention makes it possible to accomplish in particular wear resistant surfaces of almost arbitrary size, since several separately manufactured elements may be used side by side. Since the panels as well as

tapes and layers of PVD are bendable and shapable within certain limits one can also consider to achieve bent surfaces, convex as well as concave, where the shape of the surface is not given until the gluing, or in a separate shaping process which takes place immediately prior to this.

The shaping possibility means that even surfaces curved in two dimensions (spherical, for instance), can be achieved if the deformation is not too great. By embossing the tape or the sheet of metal, further a division of the surface into many small units can be accomplished, making it easier to shape it by channeling the deformations to the thinner material in the embossings, without impairing the adherence of the PVD-layer in the intermediate surfaces.

The choice of coating material, tape, panel or sheet material, as well as the used glue or adhering layer, is adapted to the intended use. The invention therefore contributes to an essentially increased freedom of increase in choice of material when constructing.

Since PVD-layers, in addition to the good wear resistance also has very low friction, one could imagine using it for accomplishing PVD-covered bearing surfaces. For some types of bearings, it is preferable to, according to tradition, secure a good transfer of heat between the bearing surface and the part belonging to it, for leading away the heat generated in the bearing due to friction. In this case, arranging a heat-insulating layer of glue between the bearing surface and the object in question may at a first glance seem completely absurd, however, since the bearing layers which are possible due to the invention can be given a very low friction, the need for the transport of heat is reduced and possible friction heat can also be led away with the help of a lubricant or through the other part of the bearing.

Further advantages and characteristics of the invention are described more closely in the following description of a preferred embodiment, shown in the enclosed drawing. In the drawing a section through the tape according to the invention is shown in a considerably enlarged scale.

The tape 1 shown in the drawing can, for instance, be composed of stainless steel. On the side of the tape, which is turned upwards, a layer 2 of PVD has been added in a vacuum chamber, the layer being made of, for instance, metal oxide, metal nitride, metal boride, carbon nitride, carbon or some other hard compound of metals, semi-conductors with oxygen, nitrogen, fluor,

boron, alternatively mixtures of such compounds. On the lower side of the tape, this is attached to a base or foundation 4 with the help of a suitable kind of glue 3.

The thickness of the metal tape (or of the panel pieces) are dimensioned so as to give a sufficiently hard support to the layer of PVD so that this at an anticipated point load is not stretched out further than is allowed by its elasticity or plasticity, so as to prevent cracks and peeling.

The metal tape does not have to be homogenous, but can, for instance, be hardened on the surface, which is faces the layer of PVD, alternatively the metal tape can comprise several layers, preferably with the hardest one facing the layer of PVD. Also the wear resistant PVD-layer may comprise several layers in order to achieve the desired characteristics. The glue can advantageously already be applied during the production of the coated tape. In this way, the glue can be applied evenly and homogeneously without bubbles, at the same time as its application in the intended place is considerably facilitated. By storing the prefabricated tape with its wear resistant surface in the form of a roll also the advantages is gained that the layer of glue holds the roll together and the layer of glue is protected by the contact with the PVD-layer of the preceding turn. The roll further becomes rugged and easy to handle. The only thing required is a pair of scissors or equivalent. If desired, the tape can be cut into desired pieces and shapes, which may be stored in staples, with the pieces adhering to each other.

The manufactured steel tape can then be sold as a rolled up wear resistant surface or bearing surface and, at use, simply be cut into appropriately large pieces, which are then attached at the right location. In order to make sure, at the cutting of the tape that no edges, burrs or similar result, which can lead to the tearing away or damaging of the surface layer, the cutting is preferably conducted in such a way, that the tape as well as the surface layer become bent towards the foundation. Alternatively, it is possible to provide the tape, right from the start, before the coating that is, with embossed grooves in which can be cut without risk. The embossings in the coated surface of steel tape do not have to be limited to the places where the tape is to be cut, but it is even possible to consider a surface with channels, either due to aesthetic reasons or for transporting cooling agents and/or lubricants.

With the help of the invention, it is even possible to use surfaces of rubber diamond (carbon nitride) for a number of applications, where this has previously been absolutely impossible to consider. Even if it is crucial that the substrate of the layer of PVD is hard, it is possible to consider that the material may be formed even after the coating for instance by bending it to circular shapes with the wear resistant surface turned either in or out depending on the purpose of usage.

In case an unyielding bearing is desired a very thin glue is used whereas in other cases a certain elasticity may be desired for the bearing as a whole, at which the layer of glue can be thicker and elastic, foamy for instance.

CLAIMS

1. A method for accomplishing a hard wear resistant surface of PVD-material on a soft foundation, characterized in that a piece of metal sheet of harder material than the foundation, is by means of a PVD-method on one side coated with a layer of PVD, which in turn is harder than the metal sheet, and that the metal sheet or parts thereof with its away from the PVD-coated facing side is then glued where the wear resistant surface is desired on the softer foundation.

2. A method for accomplishing a hard wear resistant surface of PVD-material on a large object, characterized in that a piece of metal sheet of hard material by means of a PVD-method on one side is coated with a PVD-layer that in turn is harder than the metal sheet, and that then the metal sheet or parts thereof, is glued, with its side which is turned away from the PVD-coating, to the position on the intended object, in which the wear resistant surface is desired.

3 A method according to claims 1 and/or 2, characterized in that the metal sheet has the shape of an elongate tape.

4. A method according to any of the preceding claims, characterized in that coating of PVD comprises several layers.

5. A method according to any of the preceding claims, characterized in that the surface of metal sheet facing the PVD-coating before the applying of the PVD-coating has been hardened or plated in order to achieve the required hardness

6. A method according to any of the preceding claims, characterized in that the surface of the metal sheet, which faces away from the coating of PVD, is coated with an adhesive, so that the metal sheet becomes self-adhesive.

7. A method according to any of the preceding claims, characterized in that parts with a desired shape are punched from the material, especially in such a way that the edge which result from the punching is turned away from the coated surface.

8. A method according to any of the preceding claims, characterized in that the sheet metal is bent or embossed to the desired shape before or after the coating.

9. A method according to claims 6 and 8, characterized in that the surface of glue is provided with a protective piece of removable paper or equivalent, so that a shaping in tools can take place after the application of the glue.

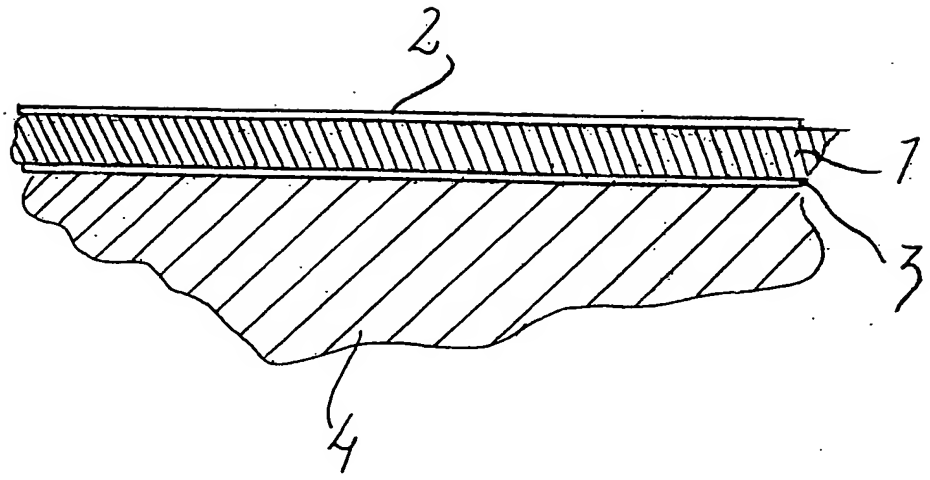
10. A part with a wear resistant surface, characterized in that it comprises a steel sheet or equivalent, which on one side has been coated with a PVD-coating and on the other side with a layer of glue.

11. A part with a wear resistant surface according to claim 10, characterized in that it comprises a substrate of sheet metal, which in itself is hard, case hardened or plated.

12. A wear resistant part according to claim 10 or 11, characterized in that the metal sheet on the opposite side of the PVD-coating has been coated with self-adhesive glue, which possibly until the time of application, is covered by a protective piece of paper.

13. A wear resistant part according to claim 10, 11 or 12, characterized in that the metal sheet has the shape of a strip or a tape, in the form of a roll, for instance.

14. A wear resistant part according to one or several of the claims 10-13, characterized in that the harder or hardened surface of the metal sheet has been coated with an even harder layer of PVD, such as carbon nitride (rubber diamond), or diamond similar carbon (DLC), possibly with metal inclusions.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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/01288

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B32B 15/18, B32B 7/02, B32B 7/12, B32B 33/00, C23C 14/06, C23C 14/24
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B32B, C23C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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